INDUSTRIAL PILOT PROJECT

Investigation of the water and pore distribution in bread using neutron and X-ray microtomography

THE INDUSTRIAL CHALLENGE

Increasing the shelf life of bread products is of great importance for Lantmännen and bread manufacturers in general. Increased understanding of water distribution and movement in bread during baking and storage can potentially be used to increase the shelf life and prolong the fresh texture of bread products.

WHY USING A LARGE SCALE FACILITY

Tomographic imaging techniques, such as neutron tomography (NCT) and X-ray tomography (XCT), are non-destructive and provide 3D views of the internal structure of materials. The high interaction of neutrons with hydrogen provides a strong sensitivity for detection of water, but at a lower spatial resolution than XCT. The objective was to benefit from the higher resolution of XCT in combination with the higher sensitivity of NCT to water and to determine the best conditions for detecting water

HOW THE WORK WAS DONE

Initial NCT measurements were performed at the IMAGINE beamline at Léon Brillouin Laboratoire (LLB) neutron facility in Saclay, France, in collaboration with AgroSUP Dijon. This enabled the experimental protocol to be optimised, including assessing potential benefits of using a Gd-based contrast agent in both normal water and deuterated water. Further measurements at higher resolution were done on proofed dough, as well as on half-baked and fully baked bread baked ex-situ with normal water. These experiments used the combined NCT-XCT beamline D50/NeXT at Institute Laue Langevin (ILL) in Grenoble, France, where also Lantmännen participated on site.

THE RESULTS AND EXPECTED IMPACT

The pre-study revealed a lower attenuation for a 10 mm thick bread piece baked with deuterated versus one baked with normal water. However, the attenuation with normal water was not too high, so this was also used during bread baking for the ILL experiments. During baking, the Gd-liquid crystalized close to the crust of the bread, which was interpreted as the final position of the liquid prior to its evaporation, Fig. 1B.

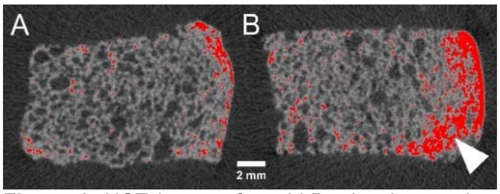

Figure 1. NCT images from LLB, showing cut bread pieces, fully baked with A) normal water and B) normal water mixed with Gd-based contrast agent. The crust on the right side (in red) shows a higher contrast mechanism. White arrowhead shows probable deposition of Gd (also in red).

The NCT experiments at ILL also revealed higher attenuation at the outer layer in proofed dough, Fig. 2 A. The proofed dough was later on baked fully (ex-situ) in an oven Fig. 2C), where the loss of contrast is most likely related to loss of water during baking. While NCT proved sensitive enough to indirectly detect water, XCT gives important information about the 3D pore structure. In all, simultaneous XCT and NCT is very promising for future studies on bread.

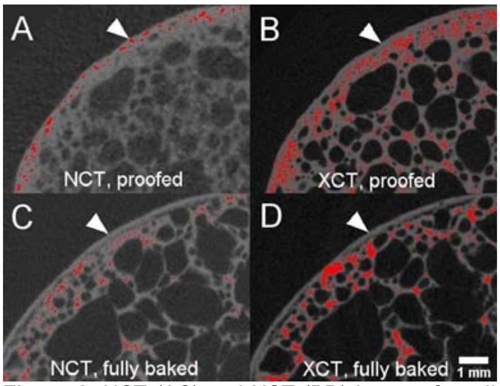

Figure 2. NCT (AC) and XCT (BD) images from ILL, showing zoomed-in views, of proofed dough (AB) and fully baked bread (CD). The arrowhead in A highlights a higher contrast mechanism with NCT emerging from the outer layer of the proofed dough, which could either be related to a higher content of water, starch or proteins in this region. The corresponding image in B is missing this contrast mechanism. The arrowhead in C displays a lower contrast mechanism emerging from the final crust, which could be related to the loss of water during final baking. Both XCT images in BD show mainly compact regions (in red).

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